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# Cultivation of Wrack Collected Seagrasses

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# **CULTIVATION OF WRACK COLLECTED SEAGRASSES**

A Thesis submitted in partial fulfillment of the requirements for the degree of  
Master of Science in  
Marine Biology and Coastal Zone Management

Submitted by:  
Irene Arpayoglou

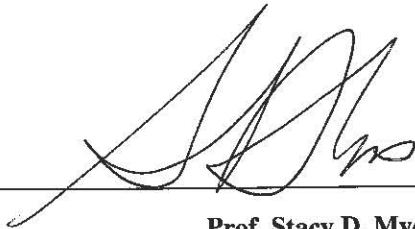
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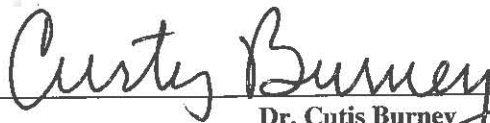
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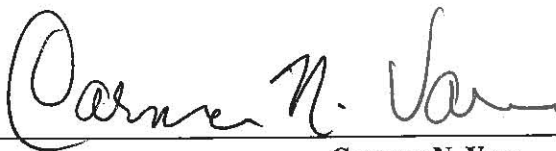
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## 1. Introduction

### 1.1 General Information

Seagrasses are extremely productive, diverse and valuable marine resources (Arrivillaga, Baltz, 1999). They include more than 50 species of vascular submerged plants (hydrophytes), which inhabit shallow coastal waters. Of these 50 species, seven are found in the waters around the state of Florida; Turtle grass (*Thalassia testudinum*), Manatee grass (*Syringodium filiforme*), Shoal grass (*Halodule wrightii*), Paddle grass (*Halophila decipiens*), Star grass (*Halophila engelmannii*), Johnson's seagrass (*Halophila johnsonnii*), and Widgeon grass (*Ruppia maritima*). *Halophila johnsonnii* is currently listed as a federally threatened species.

Seagrass meadows support very diverse fish and macro-invertebrate communities around the world and are essential nursery areas for juvenile fishes, shrimp and crabs. The meadows also support commercially important species of adult fish. Seagrass beds also enhance sediment stability, which improves water clarity and helps to decrease wave energy. Worldwide, seagrasses rank with mangroves and coral reefs as some of the most productive coastal habitats (Short, Wiley-Echeverria 1995). A strong linkage exists between seagrasses and these two habitats, making loss of seagrass habitat a factor in the degradation of the world's oceans. Many protected and endangered animals rely heavily on seagrass beds for food and shelter including such species as the Queen Conch (*Strombus gigas*) and the West Indian Manatee (*Trichechus manatus latirostris*), both closely related to the cultural identity of South Florida. The West Indian Manatee is classified as endangered under the U.S. Endangered Species Act of 1973 and is protected under the U.S. Marine Mammal Protection Act of 1972. The manatee also receives

protection by the Florida Endangered and Threatened Species Act of 1977 and Manatee Sanctuary Act of 1978. The Florida manatee forages on a variety of aquatic plants including seagrasses. Dredge and fill, as well as boating activities, destroy areas of aquatic plants that manatees feed upon,. As development and boat traffic increases in areas used by manatees, more regulations are being put into effect to protect manatees and their habitat. In October 1989 Florida approved the development of manatee protection plans for 13 counties and directed the former Department of Natural Resources to recommend priority acquisition of manatee areas under the Conservation and Recreation Lands program to strengthen aquatic preserve management plans to ensure protection of seagrass beds.

With the exception of some species that occur in rocky, intertidal zones, seagrasses grow in shallow, subtidal or intertidal, unconsolidated sediments. Their root and rhizome system form mats that bind millions of hectares of shallow water sediments, while simultaneously baffling waves and currents with their leafy canopy. The canopy traps and inhibits resuspension of fine particles, helping to clear the water column. Seagrass leaves and roots, as well as the associated epiphytes and macroalgae incorporate dissolved nutrients into plant biomass, which also improves water quality.

Seagrasses are a dominant component of many of the world's estuaries and shallow coastal waters; however, there are few locations in the world where seagrasses are as dominant as in the South Florida hydroscape. Here they occupy the position between the freshwater environments of the mainland and deep ocean. Seagrass communities stretch from the mangrove-lined estuaries of Florida Bay, the Shark River drainage, and Ten Thousand Islands out to the back reef environments and open continental shelf waters.

Due to their shallow distribution, seagrasses are vulnerable to the stresses and disturbances common in these waters. Because of their close proximity to human activity, seagrass beds are increasingly threatened in many locations, not only in Florida, but worldwide. In South Florida, seagrass beds are primarily being lost to dredge and fill activities, and to declines in water quality. Dredge and fill activities of coastal areas for navigation and development not only remove potential seagrass habitat, but also alter natural hydrological conditions. This leads to erosion, which causes an increase in turbidity and a decrease in light transmission. Modifications to natural hydrological patterns also cause changes in the salinity of coastal waters, resulting in seagrass losses. Another human activity resulting in severe (and ever increasing) seagrass losses is propeller scarring by boats. Because seagrasses are found in shallow waters that are very popular with boaters, the beds are very vulnerable to being damaged by boat propellers and anchors. When seagrass roots suffer damages caused by boat propellers, hull impacts and jet-ski scour, the damage is very difficult to repair by planting, and these grasses may not grow back for years, if ever. Sargent et al (1995) recommended a four-point plan to reduce scarring to seagrass meadows which include (1) education of the public as to the nature and scope of scarring impacts, (2) installing channel markers as aids to navigation, (3) enforcing state and federal statutes that address propeller scarring and dredging caused by propulsion systems, and (4) establishment of limited-motoring zones in areas where, due to extreme shallowness, impact would be unavoidable.

Growing interest in the economic and ecological roles of seagrass beds along with growing concern for their rapid decline has prompted efforts to monitor and conserve this valuable habitat. While more and more research is being directed towards development of

cultivation methods for seagrass bed restoration and mitigation, public education of the importance and vulnerability of seagrasses needs to be a priority, especially in Florida.

## **1.2 Problem of Seagrass Losses**

Seagrass systems have suffered serious declines in many parts of the world due to the direct and indirect effects of human impacts (Hawkins, Allen, Bray, 1999). Over the last decade, 90,000 ha. of seagrass loss have been documented in South Florida, although the actual loss is certainly greater (Short, Wyllie-Echeverria, 1995). The ever-increasing population of South Florida has been the major factor for seagrass losses. Tampa Bay has lost 25,220 ha. of seagrasses due to poor water quality as a result of dredge and fill activities, industrial discharge and sewage discharge. Chronic turbidity and siltation have greatly affected seagrass beds. Both are the result of dredge and fill activities and both reduce light penetration in the water column. Siltation covers seagrasses by a layer of fine sediments (silt), reducing photosynthesis. This fine silt also causes the waters to be turbid because it is easily resuspended due to wave action.

Between 1950 and 1982, Hillsborough Bay lost 90% of its seagrasses, Charlotte Harbor has lost 29% of its seagrasses since 1950. The hydroscape of Florida Bay, which originally supported over 500,000 ha. of seagrass prior to 1980, has changed dramatically following the onset of seagrass die-off and the initiation of widespread, chronic turbidity which have eliminated over 40,000 ha. of grasses (Durako, Hall, Merello 2002). Smaller losses include the Indian River Lagoon, which has lost over 600 ha. between 1951 and 1984 due to decreased water quality (Short, Wyllie-Echeverria 1995).



Animal activity has also been found to cause seagrass losses, but to a much lesser extent. Also, the animal activity can be considered as "natural", in which case its effects would be limited. In the summer of 1997, a grazing front of sea urchins (*Lytechinus variegatus*) was observed moving southward within a bed of Manatee grass (*Syringodium filiforme*) in Florida Bay (Macia, Lirman, 1999). Plots were placed within the seagrass beds south of the oncoming sea urchins. After passage of the urchins, the percent bottom cover of the two plots was measured. The *S. filiforme* coverage, which was initially 100%, was reduced to below 5%. The most noticeable effect of the grazing was the removal of seagrass canopy, which in some areas had been completely grazed away. Because seagrass roots and rhizomes are normally buried within the sediment and out of reach of the urchins, immediate effects of the grazing were less obvious for belowground biomass than for aboveground biomass of *S. filiforme* (Macia, Lirman, 1997). Following the grazing, the subsequent decrease in sediment depth resulted in the exposure of the rhizomes, and, within time, the below-ground biomass was also eliminated. Seagrass beds normally have a higher organic content than surrounding non-vegetated areas. Measurements of organic matter in the grazed areas increased significantly, leaving a non-vegetated but highly organic rich area. Along with the changes to seagrass bed biota, the urchin grazing has also caused changes to the physical characteristics of the sediments. Sediment grain size composition and depth are a result of the elimination of the baffling effect provided by the seagrasses (Macia, Lirman, 1999). Seagrass blades also slow the currents, allowing settlement and retention of finer particles. When the sediment is exposed, currents resuspend and carry away the finer particles, creating turbidity, which reduces light penetration into the water column. Because seagrasses need

a great deal of sunlight to grow, any reduction in the transmission of light will limit or eliminate their growth. It is almost certain that more seagrass has been lost throughout the world than has ever been monitored or observed. This makes an assessment of the actual loss impossible to determine (Sort, Wyllie-Echeverria. 1996).

### **1.3 Reasons for Losses**

There are many reasons for seagrass losses worldwide caused by disturbances. Disturbances are defined as any event that measurably alters resources available to seagrasses in such a way as to cause a plant response that results in degradation or loss (Bazzaz 1993). These disturbances can be natural or human-induced, although, reports of human-induced disturbances are increasing at a much greater rate than natural disturbances.

Natural disturbances that effect seagrasses include geological events such as coastal uplifts and subsidence, which can change the elevation of tides in some areas. Volcanic activity can scatter ash and debris, which smother coastal seagrass beds. Meteorological events such as heavy rains, hurricanes and droughts can alter the temperature and salinity in estuaries, which, in turn, can affect seagrass bed growth. Wind driven waves and currents can break seagrass leaves or uproot whole plants, leaving seagrasses piled up in wrack lines after a storm. Winds can also increase turbidity, resulting in reduced light penetration. Biological actions, such as grazing, sediment bioturbation and disease can affect seagrass beds. Animals such as herbivorous fish, sea turtles, urchins and manatees graze upon many species of seagrasses. The effects of these grazers on seagrass communities are unknown, but high densities of grazers in localized areas can produce

measurable effects (Short, Wyllie-Echeverria 1996). Bioturbation is also very important in determining the size and patchiness of seagrass beds. When benthic animals rework the sediment, they can cause a reduction in the spread of seagrasses.

Human induced disturbances include changes in water clarity due to sediment loading, resuspension and eutrophication. Human disturbances can also be directly mechanical such as dredge and fill activities and propeller scarring. Dredge and filling not only destroys seagrasses in the direct vicinity of the activity, but also has widespread and long-term effects caused by the increase in turbidity (which reduces light penetration) and changes in hydrological patterns. Changes in salinity will also affect seagrass growth and propagation. This is evident in Florida Bay, where variations in freshwater run off from the Central and Southern Florida Flood Control Project causes seagrass to die off due to abrupt changes in salinity. The run-off from the C&SF Project also carries sediments, which reduce light penetration, and fertilizers, causing algae to propagate, resulting in reduced light transmission (C&SF Project Restudy, 1999).

Because seagrass are primarily located in coastal zones, they will always be very susceptible to impacts from human activity such as nutrient loading, light reduction, and propeller scarring. As human utilization of coastal zones increases, so will the damage to seagrass ecosystems. Fortunately, seagrasses are now universally recognized as valuable habitats and efforts to mitigate their losses have been underway for many years.

#### **1.4 Wetlands Mitigation: Creation, Restoration and Enhancement**

Mitigation is the compensation for a loss caused by impacts to environmentally sensitive areas. Wetland mitigation tries to offset the loss of the benefits and functions of wetlands by providing an equivalent increase in benefits and functions in another area.

There are three main types of mitigation, which are: Creation, Restoration and Enhancement.

**Creation**- This type of mitigation involves the creation of a new wetland area where there was not one previously. For every acre of impacted wetland, 1.5 to 5 acres of new wetland area must be created (1:1.5–5 ratio).

**Restoration**- "*Returned from a disturbed or totally altered condition to a previously existing natural, or altered condition by some action. Restoration refers to the return of a pre-existing condition.*" Lewis (1989). Wetland areas that have been affected so that they no longer function as wetlands can be restored to their original condition. For every acre of impacted wetland, 1.5 to 5 acres of wetland area must be restored (1:1.5–5 ratio).

**Enhancement** – In this type of mitigation, the environmental value of a previously damaged wetland is improved. For every acre of impacted wetland, 4 to 20 acres of wetland area must be enhanced (1:4–20 ratio).

There also need to be a differentiation between *Planting* and *Transplanting*.

**Transplanting** refers to the harvesting of existing plants while **Planting** can involve cultured plants, seeding, or other methods.

Seagrass mitigation requirements have been around for over fifty years, yet there is still no set method with which to take on a mitigation project. Also, most (if not all) seagrass

mitigation projects have failed to achieve the goal of 1:1 habitat replacement, nor have they consistently addressed whether functional equivalency has been achieved (often a permit requirement).

### **1.5 The Donor Site Problem**

Seagrass transplantation has allowed investigators to explore various biological problems such as: interspecific variation; phenotypic plasticity and intraspecific genotypic differentiation and how these relate to adaptive tolerances; phenology; and the effects of different environmental pollutants on the survival, growth and development of seagrasses (Lewis, 1981). The main purpose of transplanting, though, has been to replenish stocks damaged or destroyed by human activities. There is no set method by which seagrass restoration is carried out, and a variety of trials have been done with varying degrees of success (Hawkins, Allen, Bray 1999). Most work to date has involved using seagrass material taken from an indigenous meadow called a donor site (Lewis 1981). In some cases, plants are washed free of sediments and then reburied at the transplant site. The donor grasses may be broken up into individual shoots, or left intact as a large mat of leafy shoots. Turfs are units of plants between 0.1 to 2.0 square meters, with sediment from the donor area still intact. These are dug up with a shovel or coring devices, and the depth of the turf extends below the rhizomes. A scoop harvester called the Dugong was developed in Australia (NSW) by Land & Marine for a harvesting project in Botany Bay (Fitzhenry, 1998). Seagrasses were to be harvested from an area that was to be used for the expansion of an airport runway and transplanted to another area. The harvester was a towed cutter/scoop capable of collecting 1.5 to 2 square meters of seagrass meadow per

drop. The harvester collected pre-sliced turfs, similar to those used for landscaping grass. Whereas traditional box core harvest methods would have taken 12 months, the Dugong completed the harvest within one month. But the taking of plants from a healthy bed for use as donors eventually results in the degradation of the donor site. Following the Dugong harvest, surveys were completed in the collection area to establish a seagrass count. The "after" count of grasses in the collection site represented a reduction of 98 % in the mean grass coverage of the collection site (Fitzhenry, 1998). Five months after the planting, both sites were said to be "colonizing well" although no quantitative value was given.

Plugs are circular or rectangular units of varying diameter, depending on the species. Plugs should be at least 10-15 cm deep to ensure that as much root as possible is taken. The plug method works well with most species of seagrass, but is time consuming and costly (Phillips, 1980). An area of controversy in transplanting seagrasses is the use of naphthalene acetic acid (NAPH) as a root stimulant (Zimmerman, French, Montgomery 1981).

Alternative methods include the planting of seagrass seeds. Seeds can be planted by pushing them into the sediment in areas of low current speed, but this may result in high mortality. Cylinders made from cut plastic tubes can be placed into the sediment and the seed placed inside for protection. Seeds can also be germinated in peat pots with fertilizers and then buried in the substrate.

There are various anchoring methods used to secure individual plants. These anchors can be made of construction pipes. This technique works well with *Zostera* spp. but tropical species usually die in contact with the iron (Phillips, 1980). The plants can also be fixed

to concrete rings and dropped from a boat. Small bundles of grasses can be rubber-banded to bent wire coat-hangers and the hangers inserted into the sediments. Phillips recommends that *Thalassia* plugs be planted into established beds of *Halodule*, following the natural scheme of species and process succession in the tropical seagrass ecosystems.

Despite the various techniques and research being used for seagrass restoration, this work has not prevented a net loss of this habitat. Fonseca (1992) states that 'there has never been a seagrass project which has restored more acreage than was lost. (Hawkins, Allen, Bray, 1999). Seagrass communities are very fragile, and when plants are removed from a healthy site and reintroduced to another location, problems will arise at the formerly healthy beds.

#### **1.6 Wrack Collected Seagrass: A Potential New Source of Donor Material.**

Seagrasses found in beach wrack could be a new source of donor material. These seagrasses contain roots and rhizomes, are easily collected, and relatively abundant along the shorelines. The majority of these seagrasses are the result of propellers ripping through seagrass beds in shallow areas along the coast. Until now, these grasses have floated around until they rotted. The amount of grasses that wash up on our coast is very hard to determine, but simple observation shows they are very abundant and have the potential to be used as donor material if collected early and planted in suitable sediments.

## **2. Purpose of Study**

The purpose of this study is to determine whether wrack-collected material is a viable and a potential source of donor seagrass for restoration. This study also seeks to determine if there is a difference in survival between seagrasses transplanted into aquaria and then transplanted into the field, as opposed to seagrasses that are collected and directly planted into the field.

### **2.1 Significance of Results**

If the wrack-collected material proves viable, it may reduce or eliminate the need for transplanting seagrasses from healthy beds to damaged areas. As previously stated by Fonseca, there has not been a seagrass restoration project that has restored more acreage than was lost. The ability to restore seagrass beds without the intentional degradation of a donor site will finally allow restoration projects with *almost* a no net loss of grass beds from donor sites. I say "almost" because this technique (or any other) can not allow for an absolute "no net loss" due to the fact that even wrack collected seagrasses have to come from somewhere. What this technique will allow is the use of previously wasted donor material to be saved and reused in the hopes of reducing as much as possible the need for more damage to seagrass beds.

While the use of seeds may also allow restoration without damage to healthy beds, this process requires more time in order for the seeds to grow.

Wrack-collected material provides healthy plants with root and rhizome systems in a much more timely manner. Also, permits are not needed in order to collect seagrasses from beach wrack, which will greatly expedite any restoration project.



There is no shortage of wrack material containing seagrasses that can be used for restoration projects, thanks to the amount of boaters in Florida's waterways. Seagrasses can be collected from beach wrack and planted in aquaria until they are needed for restoration, thereby establishing a supply of grasses for future projects. These seagrasses are also very easy to transport to other locations and can survive for over two weeks in water before they are planted (pers. obs).

### **3. Species Selected for Study**

#### **3.1 *Thalassia testudinum***

*Thalassia testudinum* is an Angiosperm of the Order Najadales and the Family Hydrocharitaceae, and is a characteristic plant of the Caribbean and tropical western Atlantic Ocean. It is the most abundant seagrass in the Caribbean and is found from the northern Gulf of Mexico to the northern part of South America. It is commonly known as turtle grass. *T.testudinum* is well adapted for soft sediments and occurs in relatively calm waters up to 25 m, although most beds are found in shallow waters less than 10 m with salinity of 25 to 45 ppt. *T.testudinum* plants are erect, coarse and grass-like, up to 1 m high. They cover areas as interwoven mats and are a grass-green color. The plant shoots produce a cluster of three to seven broad, strap-shaped leaves (2 cm wide), which develop from a basal meristem in the shoots, one at each node. The leaves have sheaths that surround the upper portion of the short shoots. These short shoots arise from a rhizome that is usually buried 3 to 15 cm in the substrate. The rhizome grows by means of an

apical meristem and branches first left and then right. Roots develop on the rhizomes close to the short shoots and from the base of these shoots. The plant is dioecious, with staminate flowers having a long base (pedicel). Flowering is common and occurs throughout the year, but not at the same time in all plants. Seed production occurs May through July in the northern Caribbean and extends through October in the central Caribbean.

*T. testudinum*'s distribution in Florida is most likely temperature limited. In the Gulf of Mexico it can endure warm temperatures, but along the east coast, temperatures between 35 C – 40 C will kill its leaves.

Different literature has suggested that *T. testudinum* does not tolerate variations in salinity and cannot survive in freshwater. Salinity parameters for *T. testudinum* range from 35.0 – 38.5 ppt in the Dry Tortugas but it has been found to in the Everglades National Park in salinity ranging from survive 28.0 – 48.0 ppt. (although how long it survived in these extremes was not mentioned). The maximum and minimum salinity levels in which *T. testudinum* has been found were 48.0 ppt in Florida Bay, and 10.0 ppt in Crystal Bay.

### **3.2 *Syringodium filiforme***

*Syringodium filiforme* is an Angiosperm of the Order Najadales and the Family Cymodoceacea. It is the second most abundant seagrass in the Caribbean, and is commonly known as "manatee grass". *Syringodium* occurs throughout the Caribbean and grows in pure or mixed beds with *Thalassia* and *Halodule*. Although it can tolerate

salinities as low as 20 ppt, it usually occurs in higher salinities. *S. filiforme* grows in shallow waters of less than 10 m, but can be found as deep as 18 m.

Its leaves are coarse, stiff and cylindrical, 1-2 mm in diameter. They can grow up to 45 cm high, in clusters of two to three per stalk and have a central vascular bundle surrounded by 5 – 8 air channels, and two lateral vascular bundles. The leaf sheaths are 2-6 cm long and 2m wide. Scales are present at the nodes, but shed rapidly and are rarely observed. The rhizomes are cylindrical and propagation is by damage to the existing meristem or through proliferation of the short shoots. Roots are usually produced in groups of two to three per rhizome node, and occasionally more at old leaf scars on stalks. These roots are un-branched or have few branches. The flowers and fruits are small and inconspicuous.

While *S. filiforme* is considered a tropical species because it occurs throughout the Caribbean, it is also considered eurythermal due to its distribution in northern parts of Florida. Leaf kill in *S. filiforme* occurs at temperatures below 20 C.

Along Florida's coast, *S. filiforme* does not occur north of Cape Canaveral. Occasional growth is found in the Brevard County sections of the Indian River Lagoon while dense patches can be found from Sebastian to Ft. Pierce and Port St. Lucie Inlets. Cold water in Tampa Bay can cause leaf damage to *S. filiforme* but does not occur frequently in the deeper Gulf waters.

*S. filiforme* is a euryhaline species. It is found in dense beds in Tampa Bay where salinity averages 25 ppt., and in the Indian River Lagoon where salinity ranges from 22.0 ppt – 35.0 ppt.

*S. filiforme* does not occur in fresh or low salinity water but can withstand short periods

of low salinity. In Brevard County it is found in salinity from 20.1 ppt – 20.6 ppt., and from Sebastian to St. Lucie Inlet, *S. filiforme* is found in salinity ranges of 22.0 ppt – 35.0 ppt.

#### 4. Collection

##### 4.1 Specimen Selection

The *Thalassia* specimens collected had a minimum of a rhizome, clearly developed and intact roots, and at least two leaves, which had to be green and flexible. Specimens with brittle, brown or black leaves were not chosen.



Fig.1: *Thalassia testudinum* specimen

*Syringodium* specimens with just one leaf were acceptable, as long as the leaf was thick, green and flexible, and the shoot had roots and a small piece of rhizome.

In both species, long sections of rhizomes with shoots and leaves were collected. These were kept intact, but each shoot was counted as one planting unit. If the sections were too long to place in the Zip-Loc bags without breaking, the rhizomes were cut into the largest

piece that would allow it to fit in the bag.

None of the specimens collected had any sediment attached to the root system. Any nonepiphytic organisms or other foreign materials were removed from the specimens, as well as dead leaves. Organisms such as epiphytes were not removed, unless they were feeding on the leaves.

#### 4.2 Collection Sites

Two separate collection sites were used for the two species of grasses. The sites were chosen based on how easily accessible they were and the amount of seagrasses present. *Thalassia* planting units were all collected from a site in Key Largo, Florida. The site chosen was a small marina in the Upper Keys Sailing Club. The Sailing Club is located at the end of Beach Bay Dr., on Buttonwood Sound, in Key Largo, which is on the Florida Bay (west) side of the island. This is a private club and permission from the Club management was obtained before collecting. The Club has a small marina and boat docks surrounded by mangroves. Water movement in the area allows for a large amount of seagrasses (and other floating debris) to be washed into the marina, while the mangroves provide shade to reduce the potential of the grasses that accumulate in the marina from drying out. Collection of the *Thalassia* specimens was very easy. Large amounts of suitable specimens were found in a very small area within the Sailing Club.



Fig. 2: *T. testudinum* showing root and rhizomes



Fig. 3: Wrack pile, Key Largo

The specimens were hand picked and put into one-gallon Zip-Loc bags with enough water to cover the grasses. The bags were placed in a beach cooler with ice for transport. I found that the ice keeps the water in the bags cool, and keeps the seagrasses leaf blades from becoming limp and slimy when kept overnight. The *Thalassia* specimens were collected on two separate occasions. The first collection was done on April 5, 2003 to plant an initial crop in the aquaria, which were later planted in the field site on August 28, 2003. The second collection was done on September 4, 2003. The specimens collected this time were planted directly into the field site to attempt to determine if there is a significant difference in viability between the grasses cultured in the aquaria and those freshly collected.

The *Syringodium* was collected from a second site located on the Indian River Lagoon, in Jensen Beach, Florida. The Indian River Lagoon is part of the longest barrier-island and tidal inlet system in the United States, comprising 40% of the Florida Atlantic Coast from 29° N, 81° W to 27° N, 80° N (Dawes, Hanisak, Kenworthy, 1995).





Fig. 4: Map, Indian River Lagoon

Water depth throughout the Lagoon is between 1.0 and 3.0 m. There are three openings to the Atlantic Ocean: Sebastian, F. Pierce and St. Lucie Inlets, which allow water exchange to the Lagoon. Recent estimates state that there are approximately 40,000 ha. of seagrasses in the Indian River Lagoon (Dawes, Hanisak, Kenworthy, 1995). The Lagoon supports all of the seagrasses known from the Caribbean. The collection site is an area just north of the Jensen Beach Causeway, in a small cove created by the seawall for Conchy Joe's Restaurant. As currents flow southward, seagrasses (and garbage) collect along the western shoreline of the Lagoon. *Syringodium* strands with leaves, roots and rhizomes were found floating in the water, although they were not as plentiful as the *Thalassia* were at the Key Largo site.

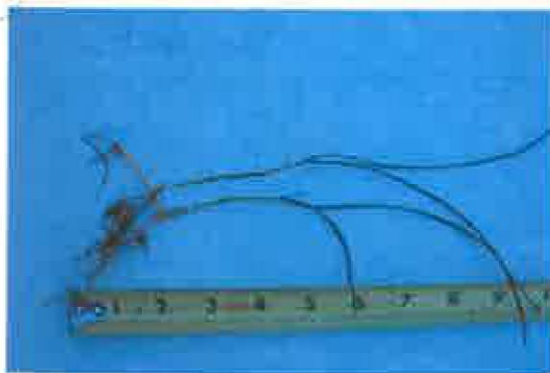


Fig.5: *Syringodium* specimen



Fig. 6: *Syringodium* ready for transport

The *Syringodium* were collected in the same manner as the *Thalassia*, placed in gallon Zip-Loc bags and transported in coolers.

Specimens were collected from "fresh" wrack piles. "Fresh" meaning wrack that was one to two days old. The age of the wrack was determined by making daily observations along different areas. Ideal conditions were after large storms or after important holidays, which draw heavy boat traffic to shallow waters, thus damaging seagrass beds and providing a chance to gather specimens. This is especially true in the Key Largo site, which had an over abundance of specimens the Monday following Spring Break week. Also, the site is located near various marinas that rent boats to tourists, who will invariably run the boat into shallow water.

The Indian River Lagoon site had a much more consistent amount of wrack material, and its abundance was more related to weather conditions and tides, than it was to boaters.

## **5. Planting**

### **5.1 Planting Experiments**

Three planting experiments were done with the collected specimens. 1) The first experiment consisted of planting the grasses in a closed aquaria system. The reason for this experiment was to determine the viability of the specimens. **Would wrack collected material survive in aquaria?**

2) Once the viability of the seagrasses was determined, they were removed from the tanks and planted at a field site. Here they would be monitored for survival. **Would the seagrasses grow in the field?**



3) The third experiment consisted of collecting wrack material of both species and planting them in adjacent field plots at the planting site. This last experiment was to determine if there was a difference in the viability and survival rates of seagrasses that were collected and placed in tanks for a length of time before planting, as opposed to being collected and planted right away, without a period in a controlled environment. **Is there an advantage of the cultivated over the freshly collected seagrass?**

## **5.2 Experiment 1: Planting in Aquaria**

### **5.2.1 Aquaria Design**

A re-circulating aquaria system consisting of ten standard aquaria, measuring 2'x2'x10" was used. The aquaria were arranged in two parallel rows on stands made of three columns of construction cinder blocks, stacked three high, with three 2"x4"x10' wood planks placed across the blocks. Styrofoam sheets were placed over the wood to prevent the aquaria from cracking once they were filled with water. Each aquaria had a 1/2" PVC overflow pipe which drained into a 1" PVC pipe that ran along the bottom and back of both rows of aquaria and into a sump. The sump was originally a 20 Gal. garbage can, which did not hold a large enough volume of water to compensate for water lost through evaporation. This sump was eventually replaced with a larger 70 Gal Rubbermaid Cattle Tub. The larger sump reduced suspended sediments and the need for continuous water replenishment.



Fig. 7: Aquaria setup



Fig.8: New sump and shade cloth

Water circulation was originally provided by means of one 500 GPH submersible pond pump, which proved to be insufficient for ten aquaria. Before the seagrasses were planted, a second 500 GPH pump was added to increase water flow. Both pumps were in the sump, but each one only provided water flow to one of the two rows of aquaria so each aquaria had a flow rate of approximately 100 GPH.

To reduce the growth of algae in the aquaria, a cover was placed over the entire system. The cover was made from 50% shade cloth, folded over on it-self and attached to a PVC frame. A smaller cover made of black plastic sheeting was placed over the sump to prevent any further algae growth.

### 5.2.2 Water Supply

Natural (untreated) seawater was used for the aquaria and was collected from the Indian River Lagoon at the Ft. Pierce inlet. The frequency of water replenishment was determined by three factors: 1) the rate of evaporation in the tanks; 2) the amount of rainwater that entered the tanks causing the salinity to drop; and 3) the amount of water lost through slight leakage. The water was placed directly into the sump without any previous filtration or treatment.

### 5.2.3 Sediments

Each aquaria was filled with approximately three inches of natural beach sand. The sand was gathered from local beaches (Ft. Pierce) and from the Indian River Lagoon. Large and extraneous objects were removed from the sand before being placed in the tanks, which already contained water. The sediment was allowed to settle for two days before the pumps were turned on.

### 5.2.4 Planting

Once collected, the specimens were planted in ten aquaria. Five were used for *Thalassia* and five for *Syringodium*. Each tank was planted with fifty (50) specimen, for a total of 250 *Thalassia* and 250 *Syringodium*. Planting was done by simply burying the specimen in the sediment, making sure to completely cover all the roots and rhizomes. No anchoring methods were needed in the aquaria.

The specimens were arranged at random in each aquaria, (not planted in rows) depending on their size and length of the rhizomes as to allow room for all fifty planting units.

After a growing period of approximately five months (April 2003 to August 2003), the planting units were removed in order to be planted at the field site. At this time a count of the surviving planting units was done in order to determine the survival rate of both species.

### 5.2.5 Monitoring of Aquaria

The aquaria were monitored for water temperature and salinity on a weekly basis. Each tank had a common floating pool thermometer, and temperature readings were taken at the same time of day for each aquaria. There were some minor temperature differences (average of 1°C or smaller) from one aquaria to another, mainly due to the amount of shade and sunlight that each one received.

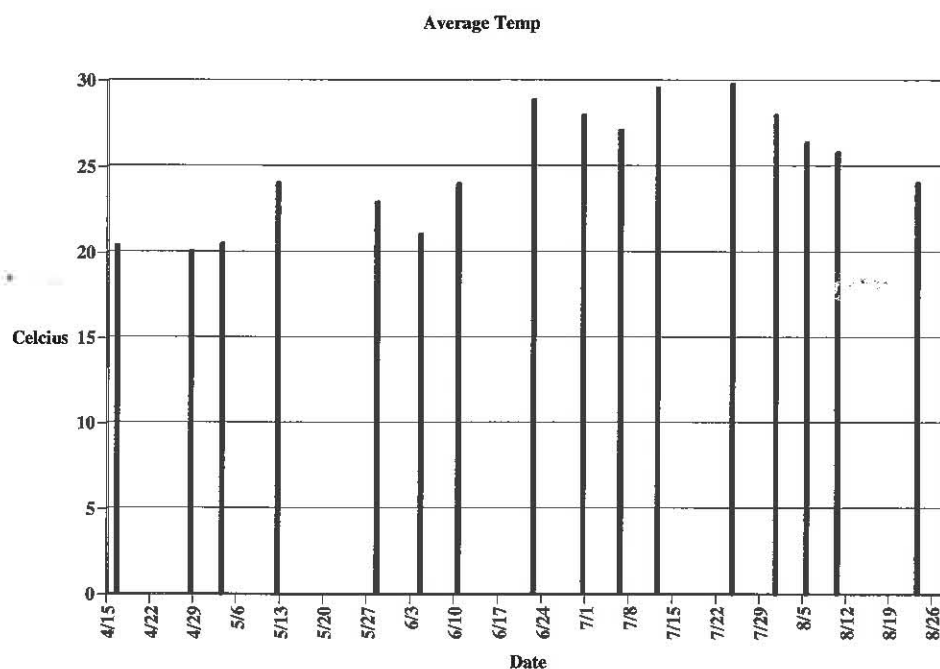


Table 1: Average Temp. in Aquaria

Salinity was monitored using a Portable Refractometer. The salinity was measured from the sump, and not from each aquarium individually, as this reading was the same in all the aquaria.

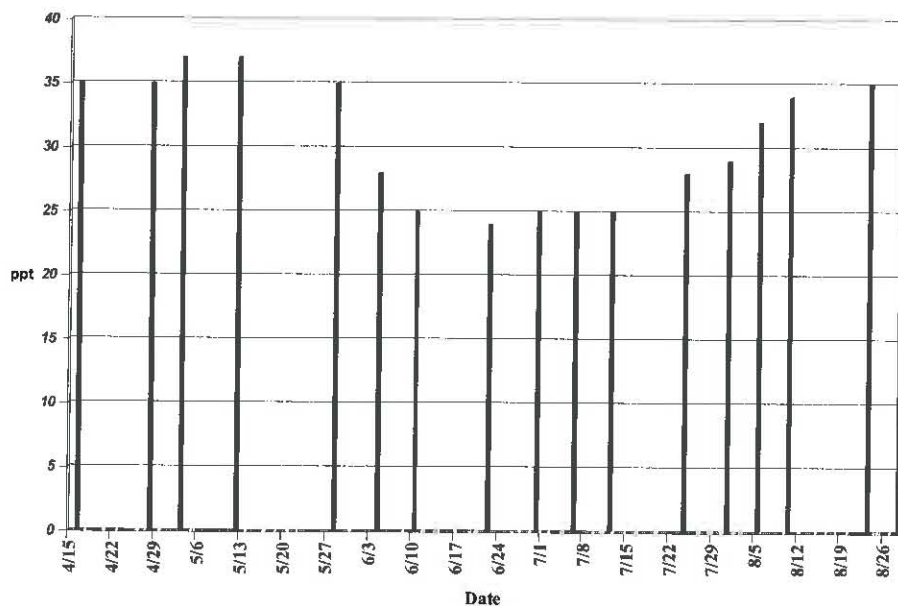


Table 2: Salinity in Aquaria

Water clarity was monitored to control the growth of algae in the tanks. When filamentous algae did become a concern, it was simply pulled out of the tanks. A small bloom of algae did cause the water to acquire a green tint. This was remedied by performing subsequent water changes and by the addition of the shade-cloth cover to the system.

Light intensity in the aquaria was also monitored. A HOBO Light Monitor was used for this. The light monitor was placed inside a watertight container and attached to a 2 lb. Diving weight to keep it at the bottom of the aquaria.

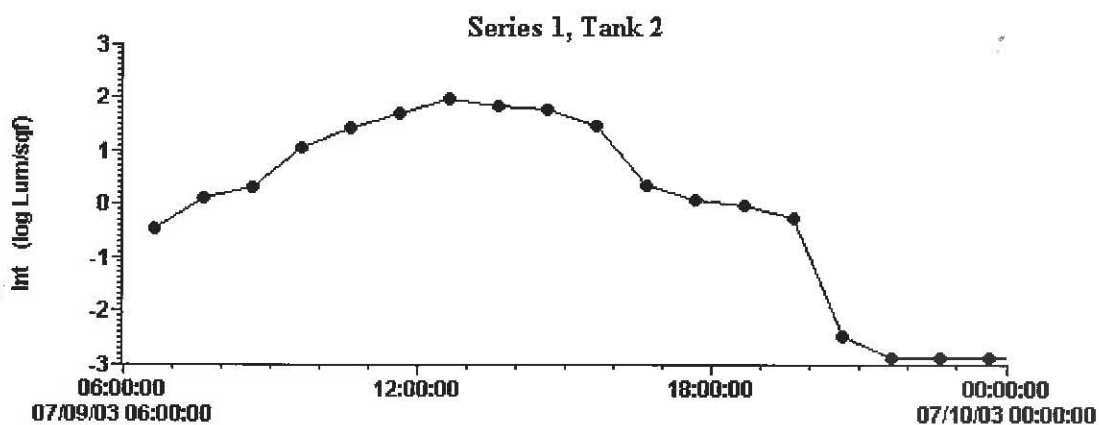
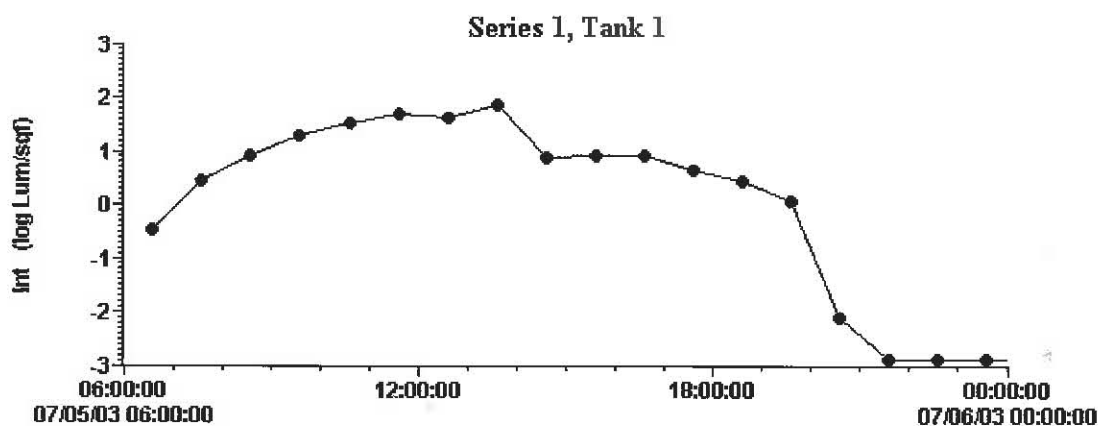


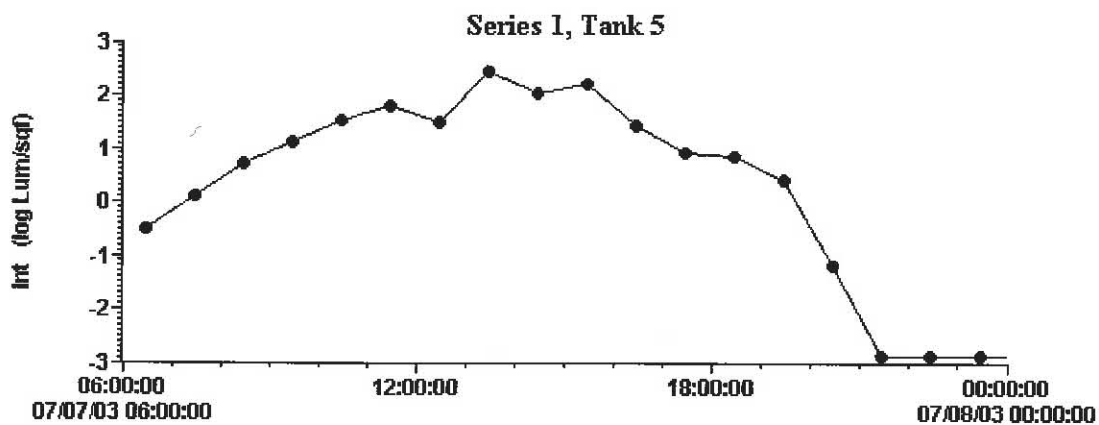
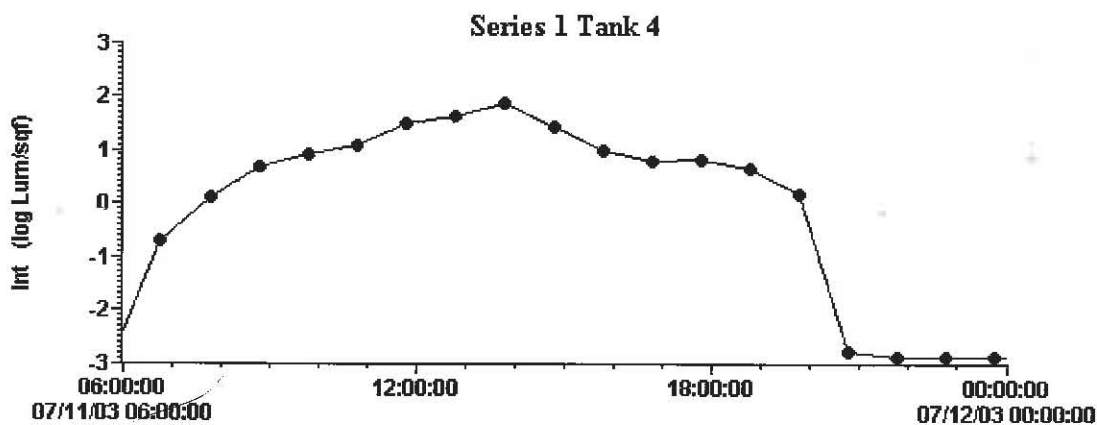
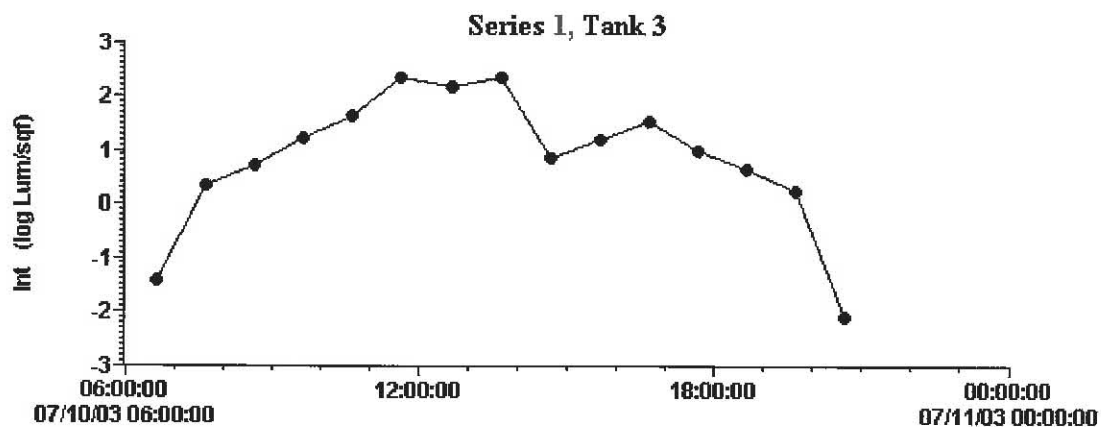
Fig. 9: HOBO Light Meter and Container w/weight

The monitor was placed in each aquarium for a period of 24 hours. This was conducted over a period of twenty days to establish two 24hour readings per aquaria. The following

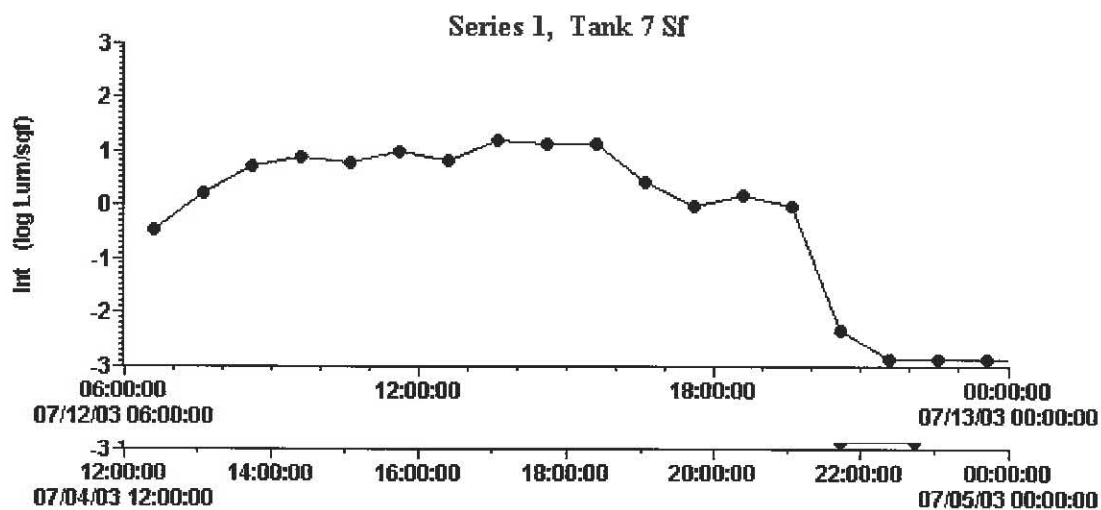
graphs are from the first series of readings taken. Because both series of readings are so similar, the second series graphs are not listed.

**Light Intensity Readings for Tanks 1 – 5, *Thalassia testudinum***  
Tables 3-7

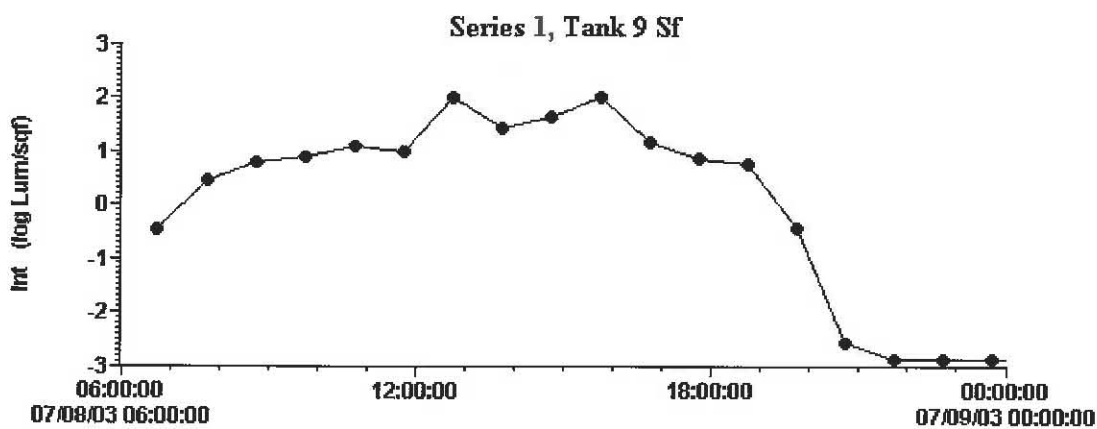
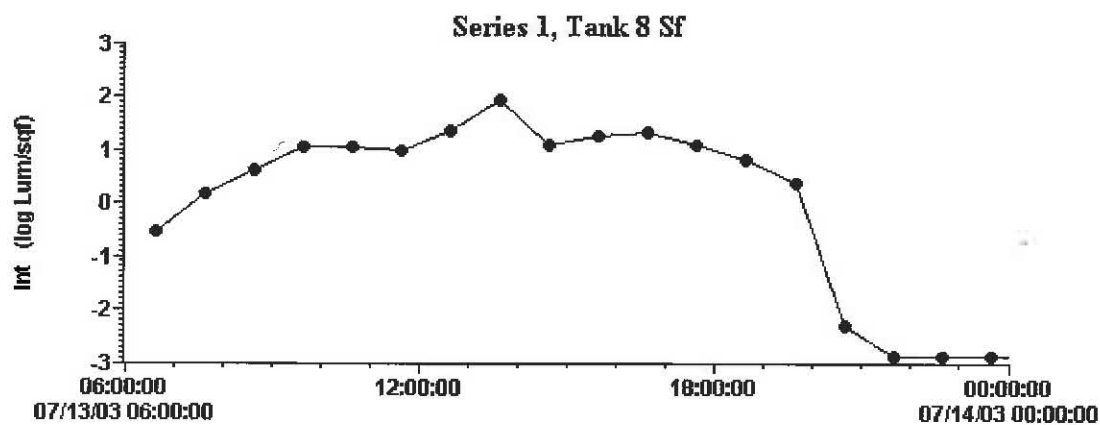




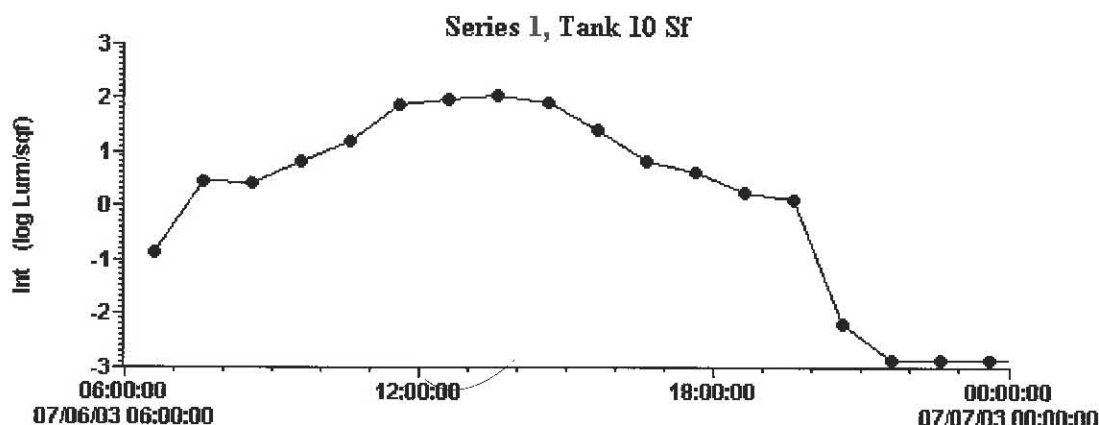
# Light Intensity Readings for Tanks 6 – 10, *Syringodium filiforme*



Tables 8-12







### 5.3 Experiment 2) and 3) Planting in the Field

#### 5.3.1 Location for Field Study: Light Harbor Site

Once the grasses proved to be viable in the tanks, they were transplanted to determine their viability and survivalship in the field for the second experiment. Freshly collected grasses were also planted in the field for the third experiment.

The site used for this purpose is called the Light Harbor Site, located in the Lake Worth Lagoon.

The Lake Worth Lagoon is located in Palm Beach County and is the major estuarine body in the county. The Lagoon is about 20 miles long, 0.4 miles wide, and has an average depth of 6 to 10 feet and is separated from the Atlantic Ocean by barrier islands.

The Lake Worth Lagoon was described as a freshwater lake by settlers as recently as 1830. Freshwater marshes surrounded the lake, and freshwater grass beds grew within it. The main sources of water for the lake were rainfall, groundwater seepage and surfacewater runoff from the west (Lake Worth Lagoon Management Plan, 1998). In

1877 the first stable inlet was constructed and the Lagoon began a gradual change from freshwater to saltwater. The Intracoastal Waterway, which runs from the south end of the Lagoon to Biscayne Bay, was also completed in the early 1900s. Only three natural islands existed in the Lagoon but when the inlet was deepened to 16 feet in 1925 with Peanut Island formed using the dredged spoil material.

Presently, Lake Worth Lagoon is connected to the Atlantic Ocean by two inlets, The Lake Worth Inlet (Palm Beach Inlet) and the South Lake Worth Inlet (Boynton Inlet). The north inlet is 400 feet wide and 35 feet deep, while the south inlet is 200 feet wide and 6 feet deep. The Atlantic Intracoastal Waterway runs the entire length of the Lagoon, and eight bridges connect the barrier island to the mainland. Approximately 65% of the shoreline is seawall, with hundreds of private docks and marinas found throughout the lagoon. Only 19% of the shoreline still has mangroves.

Natural sediments in the Lagoon are comprised mainly of sand or shell fragments and sand. In the last 100 years, fine-grained silt and clay have accumulated in areas downstream from freshwater discharge points and dredge holes. These enriched organic sediments form muck, which contributes to the turbidity and reduced light penetration in the water column (Lake Worth Lagoon Management Plan, 1998).

The actual planting site is located in Riviera Beach just south of the Blue Heron Bridge, and to the west of Peanut Island. The site was chosen for many reasons, primarily because it was an already designated Seagrass Monitoring site by the Department of Environmental Resource Management. It is easily accessible by land through a marina/shipyard, or by boat during high tide. Depth at low tide is about 2 ft. and at high tide it is about 5 ft. Visibility is highest at flood tide and is around 20 ft. After high tide,

visibility drops to about 5 ft. or less. The sediments are very fine and easily disturbed, reducing visibility even more. The site is very barren, but does have some growth of *Halophila dicipiens* (Paddle Grass), *Halophila johnsonii* (Johnson's Seagrass) and *Caleurpa* (algae). There is some floatsum from the marina, mainly empty bottles, cans, construction rubble and old tires. The marina provides shelter to the site on two sides, the north side (by a pier) and the west side (seawall). The wave action is lower than at non-sheltered areas of the Lagoon, with no boat traffic directly over the site. The marina does have a boatlift on the pier approximately 100 ft. north, and there is a lot of boat activity there. Benthic animals include sea urchins (*Lytechinus variegatus*) hermit crabs (species not identified), and Queen Conch (*Strombus gigas*). There are also fish such as Mojarras (*Eucinostomus* spp.), small barracudas (*Sphyraena barracuda*), needle fish (*Platybelone argalus*), puffers (*Sphoeroides testudineus*, *Diodon holocanthus*, *Chilomyterus* spp.) and sea horse (*Hippocampus* spp.). A logger head sea turtle hatchling (*Caretta caretta*) was also found swimming around the site (which was taken to Juno Beach Marine Life Center).



Fig. 10: Light Harbor Site, North view



Fig. 11: Light Harbor Site, South view

### **5.3.2 Permitting**

Permits were not required for the collection of both species, as this was to be done above the mean high tide line. The seagrasses were found among floatsum , which, regardless whether it is in the water or not, does not require a permit to collect.

Once viability is established, a permit may be required for planting in the field if the water body has been deemed Sovereign Submerged Lands by the State. A second scenario would be if the area used is artificially created water bodies, no permit is required (pers. Com. Jayne Bergstrom, Permitting Program Manager Environmental Resources Program). The third scenario would be the Light Harbor site which is already a designated seagrass restoration site, with no permitting was necessary to plant the grasses. (There is not an ongoing project at the site, but it is being monitored for the presence of seagrass).

### **5.3.3 Planting in the Field**

Field planting was done on three separate occasions, the first on August 28, 2003. Before planting, the seagrasses were removed from the aquaria, counted, photographed, and placed in Zip-Loc bags with sufficient water to keep them hydrated. Any sediment that was attached to the roots and rhizomes was left intact, as well as any dead or dying leaves. All the bags were labeled with species, number of individuals and aquaria number, and placed into coolers.

Once at the site, the seagrasses were planted in two separate plots according to species. Planting (on this occasion) was done at low tide using snorkel gear. No anchoring methods were used and all the specimens were planted by hand. A hole was dug in the

sediment with one hand about 10.0 cm. (until the sand created suction) and the seagrass was placed in the hole, the roots and rhizome were then covered with the surrounding sediment. Three people planted 132 *Thalassia* specimen and 211 *Syringodium* specimen in approximately one hour.

The second planting was done on September 12, 2003 using *Thalassia* units collected from the Key Largo site and planted directly into the field. This was done in the same manner as the previous planting. This time, however, the planting was done by myself, at high tide, using SCUBA gear. The planting took approximately two hours. About 200 *Thalassia* planting units were planted.

The last planting was done on September 22, 2003, using *Syringodium* collected from the Indian River Lagoon early that morning. This planting was also done by myself, at high tide, using SCUBA, and took approximately two hours. About 200 individuals were planted.

A total of four plots were planted; two using *Thalassia*, and two using *Syringodium*. Of these four plots, two were planted with plants collected and raised in the aquaria (experiment 2), and two were planted with individuals collected on either that same day, or the day before, but not raised in aquaria (experiment 3). No anchoring devices were used in any of the four plantings.

After each plot had been planted, they were marked off using segments of PVC pipe hammered into the sediment. The PVC was placed at the corner edges of each plot to mark off (roughly) a square area. The two original plots with the tank-raised individuals were marked off with PVC spray painted pink for *Thalassia* and green for *Syringodium*. The other two plots with the non tank-raised individuals were marked off with unpainted

PVC. The perimeter of each plot was measured using a Stanley waterproof contractors tape measure. Each plot measured about 5' x 4' (+- 8 inches).

#### **5.3.4 Monitoring of Field Plots**

After the first planting, the plots were monitored every three days to ensure that the seagrasses would stay fixed in the sediments. After the first two weeks, visual inspections were done on a biweekly basis. The inspections consisted simply of swimming out to the site to ensure that the PVC markers were still in place, make general observations of the seagrasses or of any epiphytic growth on them, and visually identify other organisms in the area (fish, crabs, sea urchins, conch, etc.).

Salinity readings were not taken because the site is located in close proximity to the Palm Beach Inlet, and salinity in the area is that of seawater.

Light intensity readings were done using the HOBO Light Monitor. The monitor was programmed to take light readings every hour for a period of seven days. Because the monitor is not waterproof, it is placed in a clear plastic waterproof canister, and attached with plastic cable ties (zip-ties) to a weight. The canister was placed next to one of the painted PVC markers. After three days, I returned to the site to check on the monitor and clean off any algae growth, which could interfere with the collection of data. The canister had slight algae growth, but otherwise it was fine, it hadn't shifted or been covered by sediment, and the monitor inside was still working. The following chart shows light readings over the course of seven days.

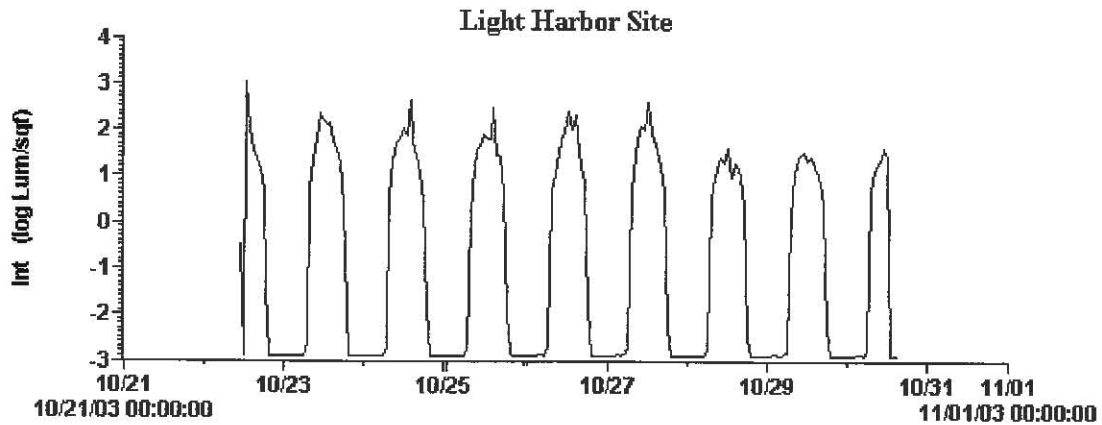


Table 13: Weekly Light Readings, Light Harbor Site

The following chart shows light readings over the course of one day (October 23, 2003) take at one-hour intervals. The readings varied very little from those in the tanks.

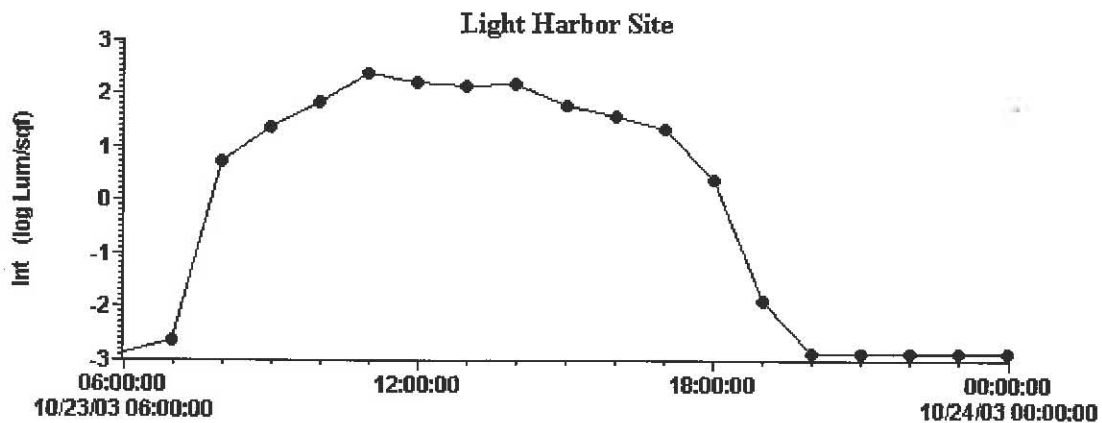


Table 14: Daily Light Readings, Light Harbor Site

After a period of three months in the field, a final count was done on all the surviving planting units from experiments 1 and 2. The count was preformed using a 1 m.X 1m. quadrat divided into 10 cm. X 10 cm. Squares. This was laid over the planting plot in

order to allow the grasses in each square to be counted only once. Once the grasses within the entire quadrat were counted, the quadrat was flipped over and the next section of the plot was counted. This was done over the entire plot, so that all the planting units from all four plots were counted.

## 6. Results

### 6.1 Viability and Survival in Aquaria

#### *Thalassia testudinum*

Table 15 shows the initial and final counts of the *Thalassia* planting units and the survival rates (expressed as percentages). The average survival number of planting units was 26.4 individuals, **while the average survival rates was 52.8 %**.

Table 15: Survival of *Thalassia* planting units in 5 aquaria before field transplantation

	Initial PU April	Final PU August	Survival %
Tank 1	50	31	62.00%
Tank 2	50	27	54.00%
Tank 3	50	24	48.00%
Tank 4	50	16	32.00%
Tank 5	50	34	68.00%
	<b>250</b>	<b>132</b>	<b>52.80%</b>

#### *Syringodium filiforme*

Table 16 shows initial and final counts of planting units, as well as the survival rates. Average number of surviving units was 42.2 individuals, **while average survival rate**



was 84.4 %. Tanks 9 and 10 had a larger final count than initial count. This was due to the growth of *Syringodium* shoots in the tanks from the collected material.

Table 16: Survival of *Syringodium* planting units in 5 aquaria before field transplantation

	Initial PU April	Final PU August	Survival %
Tank 6	50	16	32.00%
Tank 7	50	48	96.00%
Tank 8	50	34	68.00%
Tank 9	50	55	110.00%
Tank 10	50	58	116.00%
	250	211	84.80%

The average number of overall (both species) surviving units was 34.3 planting units, while **average survival rate was 68.60%**. A One Way ANOVA performed to determine if there was any significant difference between the survival rate of the *Thalassia* and the *Syringodium* planting units showed **a significant difference between surviving planting units (P 0.014)**.

When planting units were placed in the aquaria, they had no sediments attached to their roots. Upon removal for planting, both species showed sediment attachment to roots and rhizomes.



Fig. 12,13: *Thalassia* planting units showing sediment attachment to roots



Fig. 14,15: *Thalassia* planting units showing sediment attachment to roots

Sediment attachment was much greater on the *Thalassia* planting units than on the *Syringodium* units. This may be due to the larger rhizomes on *Thalassia*.

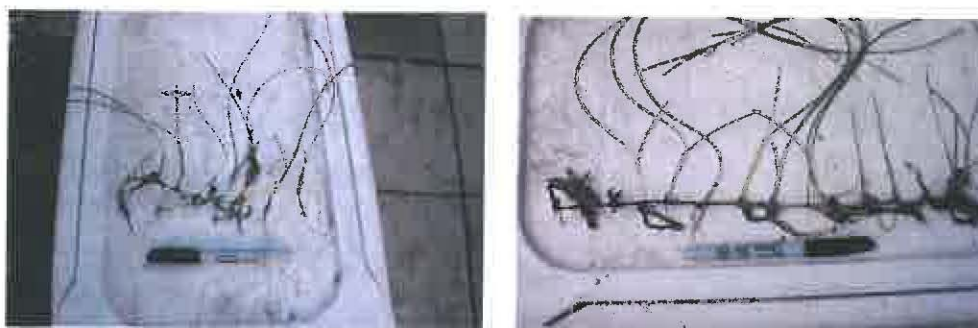


Fig. 16,17: *Syringodium* planting units showing sediment attachment to roots

## 6.2 Viability and Survival of Aquaria Raised Seagrasses in the Field

Table 17 shows the results of the field transplantation study. The initial number of *Thalassia* planting units from the aquaria was 132. After three months, 83 planting units survived. This gave a **field survival rate of 62.88% for the Tank Raised *Thalassia* planting units**. The initial number of *Syringodium* planting units was 211, with a final count of 28. The **field survival rate for *Syringodium* was only 13.27% for the Tank Raised units**. This low survival rate may be the result of grazing on the seagrass by

predators such as sea urchins (which were commonly found in the plot during visual observations).

Table 17: Results of the first field transplantation study of aquarium grown seagrasses

	Initial PU August	Final PU November	Survival Rate %
<i>Thalassia</i>	132	83	62.88%
<i>Syringodium</i>	211	28	13.27%

### 6.3 Viability and Survival of Field Collected (non-aquaria raised) Seagrasses

The third and final experiment was done using seagrass units which were collected and planted in the Light Harbor Site without first being planted in the aquaria. This was done to determine if there was a significant difference in the survival between those grasses and the grasses that had been planted in the aquaria. The initial number of *Thalassia* planted at the Site was 200 planting units. Table 18 gives the survival rates of freshly collected seagrass wrack. After three months, 81.5% of the *Thalassia* and 49.0% of the *Syringodium* planting units survived.

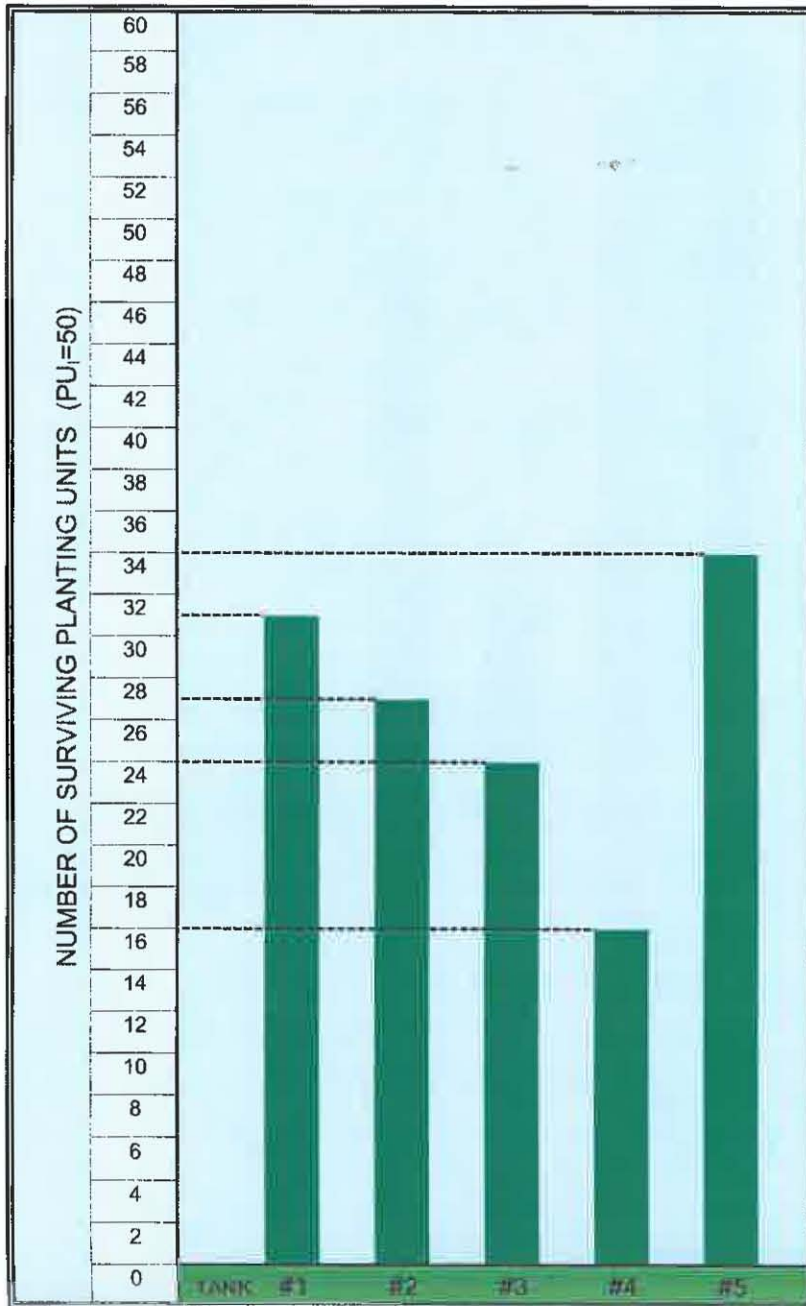
Table 18: Results of the freshly collected seagrass wrack field transplantation study

	Initial PU September	Final PU December	Survival rate %
<i>Thalassia</i>	200	163	81.50%
<i>Syringodium</i>	200	98	49.00%

While these rates seem high compared to the *Aquaria-to-Field* trials, there were also differences between the two sets of seagrasses. The most important factor is the amount of handling the *Aquaria-to-Field* grasses received. They were first uprooted and washed ashore, then they were collected, bagged, planted, and allowed to "recover". Afterwards,

they were uprooted again, bagged again, and replanted again. The Field collected grasses were only uprooted, bagged and planted once. Also, the Aquaria grasses were observed for a longer period of time than the Field collected grasses. Perhaps, after a period of three more months in the field the survival rates of both experiments will be more similar to each other.

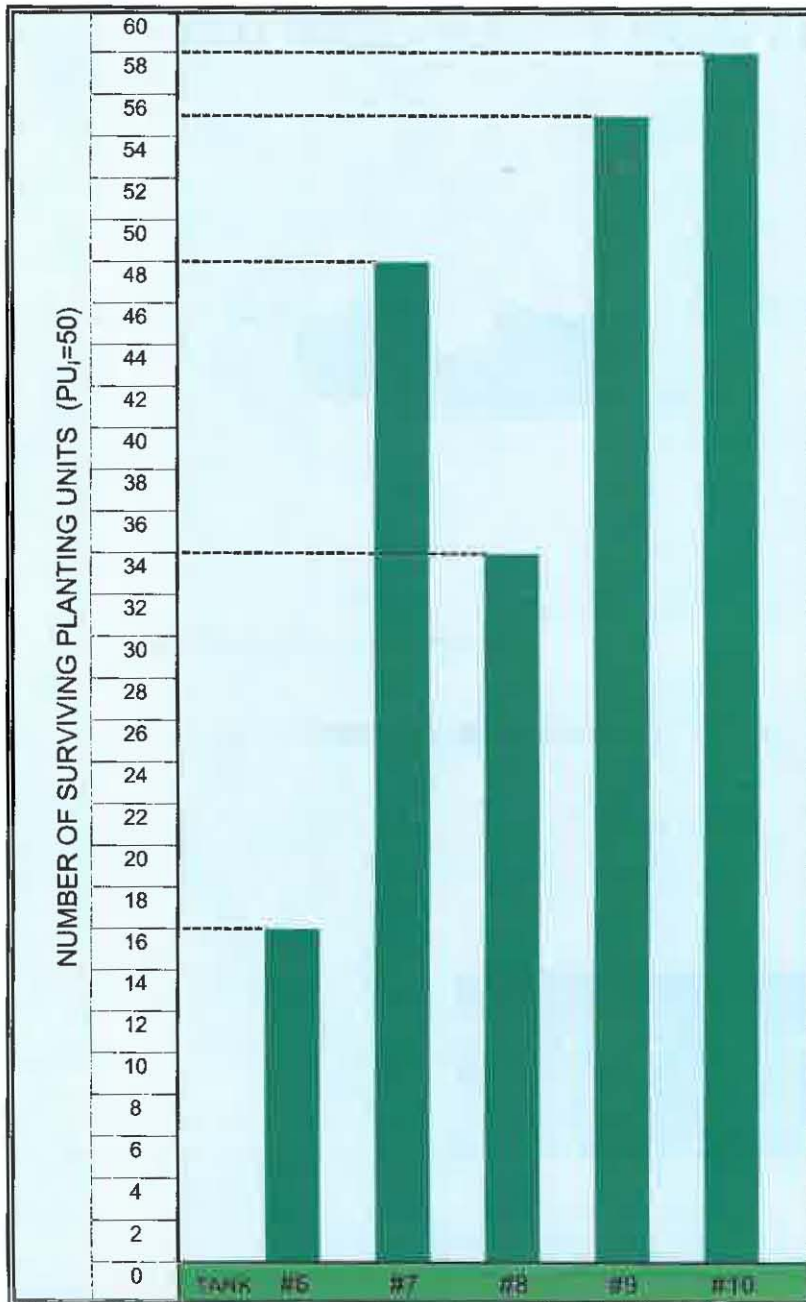
## *Thalassia testudinum* in aquaria



TANK #1	50	31	62.00%
TANK #2	50	27	54.00%
TANK #3	50	24	48.00%
TANK #4	50	16	32.00%
TANK #5	50	34	68.00%
<b>TOTAL</b>	<b>250</b>	<b>132</b>	<b>52.80%</b>
	INITIAL COUNT	FINAL COUNT	SURVIAL RATE %

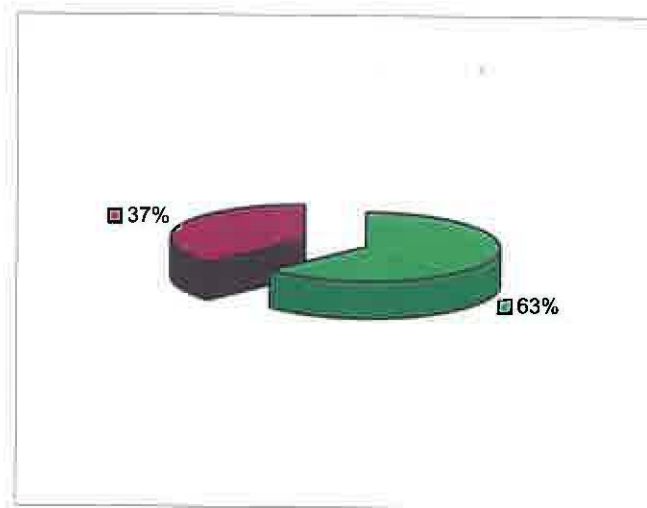


## *Syringodium filiforme* in aquaria



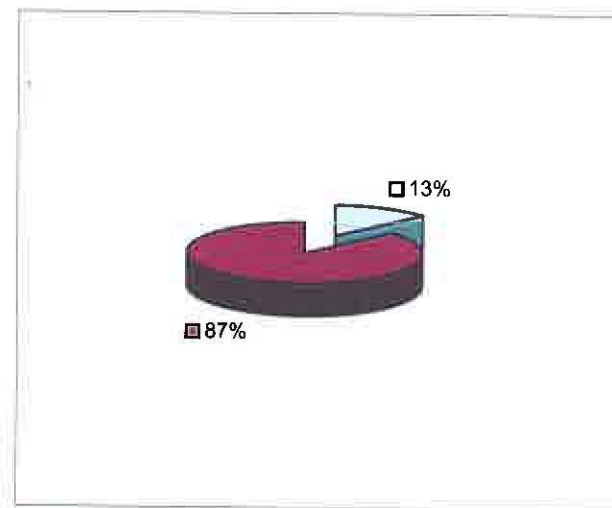
TANK #6	50	16	32.00%
TANK #7	50	48	96.00%
TANK #8	50	35	70.00%
TANK #9	50	55	110.00%
TANK #10	50	58	116.00%
<b>TOTAL</b>	<b>250</b>	<b>212</b>	<b>84.80%</b>
	INITIAL COUNT	FINAL COUNT	SURVIAL RATE %

## FIELD TRIAL RESULTS FROM AQUARIA RAISED PLANTING UNITS



Planting Unit Survival Rate

***Thalassia testudinum***

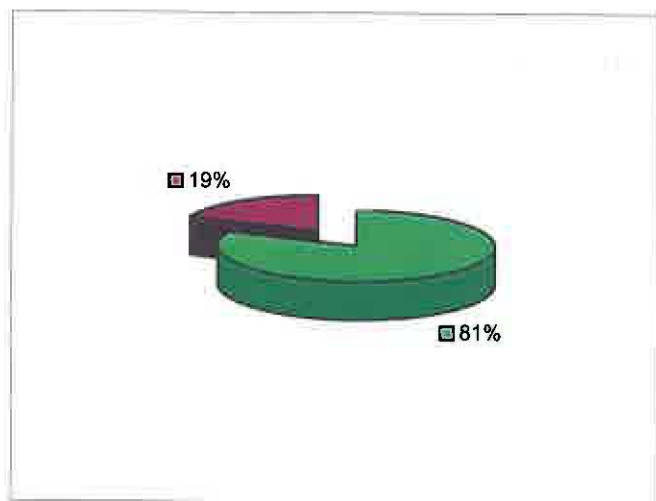


Planting Unit Survival Rate

***Syringodium filiforme***

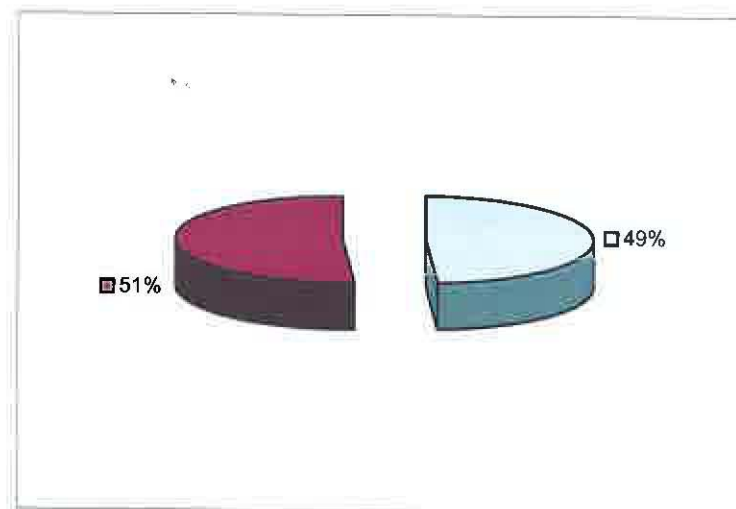
Tt	132	83	62.88%
Sf	211	28	13.27%
	INITIAL COUNT	FINAL COUNT	SURVIVAL RATE %

## FIELD TRIAL RESULTS FROM NON-AQUARIA RAISED PLANTING UNITS



Planting Unit Survival Rate

***Thalassia testudinum***



Planting Unit Survival Rate

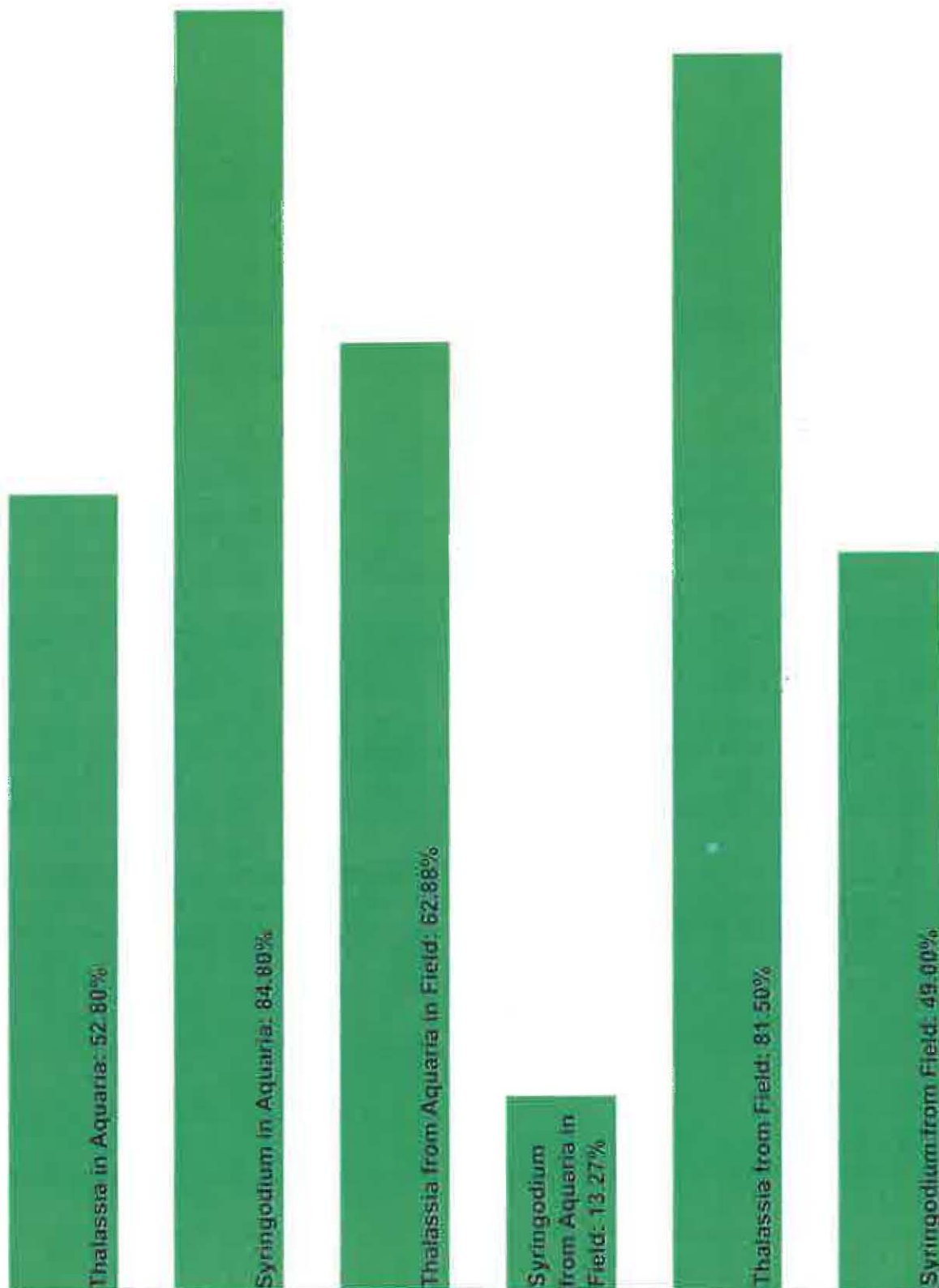
***Syringodium filiforme***

Tt	200	163	81.50%
Sf	200	98	49.00%
	INITIAL COUNT	FINAL COUNT	SURVIVAL RATE %



## OVERVIEW OF SURVIVAL RATES

100%  
95%  
90%  
85%  
80%  
75%  
70%  
65%  
60%  
55%  
50%  
45%  
40%  
35%  
30%  
25%  
20%  
15%  
10%  
5%  
0%



## 7. Observations, Discussion and Recommendations for Future Work

With this study, wrack-collected seagrasses have shown to be a viable source of restoration material.

	Tank	Tank/Field	Field	Average Survival
<i>Thalassia</i>	52.80 %	62.88 %	81.50 %	65.73 %
<i>Syringodium</i>	84.80 %	12.27 %	49.00 %	48.96 %

Table 24: Overview of survival rates of all three planting experiments

The survival rates of the wrack collected *Thalassia* planting units was similar to its survival in a traditional restoration project using a donor site in Biscayne Bay by the Dade County Department of Environmental Resource Management (Large-Scale Seagrass Restoration in a Damaged Estuary, Anita Thorhaug). Planting was done using *Thalassia* and *Halodule* sprigs over a 9.09 ha. area. After a period of 12 months, the survival rate of *Thalassia* in depths similar to those used at my field sites ranged from 87.5% to 88.8 %. Although my study did not span such a large time frame, follow up work could involve a longer monitoring period.

If collected shortly after being uprooted, the grasses can survive either in the aquaria or in the field. *Thalassia* was by far easier to collect, and the planting units were in much better condition than *Syringodium*. This is probably because the *Thalassia* plant is more robust and more resistant to being knocked around by waves and currents. Once the seagrasses were collected and planted in the aquaria, they required little upkeep, mainly just keeping the water levels in the sump up, the algae down, and the salinity in check with regular

water changes. A variety of organisms began to flourish in the tanks, from macroalgae to small fish (which must have been introduced as eggs or fry) and everything in between. The following is a list of some of the organisms identified in the aquaria.

### **Other Organisms found in Aquaria**

*Halimeda tuna* Stalked Lettuce Leaf Algae

*Dasycladus vermicularis* Fuzzy Finger Alga

*Microdictyon boergesenii* Green Net Alga

*Acetabularia calyculus* Green Mermaid's Wine Glass

*Wrangelia penicillata* Pink Bush Alga

*Cassiopea xamachana* Mangrove Upsidedown Jellyfish

*Viatrix globilifera* Turtle Grass Anemone

*Alicia mirabilis* Berried Anemone

*Arachnanthus nocturnus* Banded Tube-dwelling Anemone

*Bispira variegata* Variegated Feather Duster

*Spirobranchus giganteus* Christmas Tree Worm

*Bulla striata* Striate Bubble

*Bursatella leachii* Ragged Sea Hare

*Pinna carnea* Amber Penshell

*Eucinostomus jonesi* Slender mojarra

Costs for this project were minimal. The materials included ten aquaria (borrowed from Nova), two sump pumps, a Rubbermaid cattle drinking tub, Zip-Loc bags, some lumber

and cinder blocks, and countless sections of PVC pipes. The fact that the planting site was easily accessible from land helped greatly to reduce costs because a boat was not needed for this project.

In a full-scale project to collect seagrasses from wrack, the biggest expense would most likely be the man-hours needed to gather adequate planting units, as well as the actual planting. Because the grasses can be kept alive and healthy for long periods of time in aquaria (> 2 months), the collection process can be completed over an extended period of time. The grasses can also be collected when conditions are favorable and held in aquaria until a project comes up. Favorable conditions could be after a large storm or after a holiday when more boaters are on the water (and on seagrass beds). Because tourist season in Florida coincides with winter (which is a dormant period for seagrasses), grasses can be collected and placed in aquaria until the beginning of their growing season and then transplanted.

While both species of seagrasses held up well to being handled, the difference in survival between the aquaria raised grasses and the ones harvested and planted right away may be due to stress on the roots from being transplanted and uprooted. The other factor in the field trial survival rates seemed to be predation on the seagrasses. All the planting units seemed to be surviving at a similar rate, and all of the sudden, all the leaves were missing from the *Syringodium* plots. Maybe some form of exclusion device could be developed to protect the transplanted grasses, but that would only work on a small site. A large site would be too difficult to protect while avoiding damage to other marine life.

A future experiment could involve planting the grasses in peat pots until they are needed for a project. The grasses can then be planted directly into the sediments while in the pots

to reduce the amount of stress on the roots. This would also provide a form of anchoring for the seagrasses.

A second project would be to use a much larger planting site and more planting units. This site would be monitored for a longer period of time ( $> 1$  year) to determine survival rates over various growing periods. A longer monitoring period would also allow a study on sediment composition to see if the grasses produced any changes in the sediments.

A third project could be done using species other than *Thalassia* and *Syringodium*. Although this would be much more difficult and time consuming due to the fact that planting units of other species are much less abundant. The only other species found somewhat easily while collecting planting units was *Halodule wrightii*, Shoal grass (the third most abundant seagrass in the region). Species such as *Halophila decipens* and *H. johnsonii* were present, but very scarce. This is probably because the plants are more delicate and fragile and will tend to be destroyed by wave action and currents.

After all is said and done, by far, the most inexpensive and effective plan of action for seagrass restoration and protection is education and public awareness. The most common cause of habitat destruction (any type of habitat) is lack of information. Most people do not know about seagrasses and the role they play in the environment. While doing work on this project I met a lot of people that spent a great deal of time on the water and had no idea what seagrasses were (most just considered them sea-weeds or algae). When I explained the importance of seagrass habitats and how easy they were to destroy, they all had the same comment, "I had no idea". Seagrasses are something that can be easy to market to the public if they are tied in with something more appealing and tangible. People that fish for sport or derive their livelihood from fishing need to understand how

seagrass beds serve as hatcheries and nurseries for fish. Scuba divers can be taught about sediment fixation, which improves water clarity and visibility on reefs. And the ever-present manatee and sea turtle huggers need to know that in order to protect these animals they need to preserve their habitats, which include seagrass beds.

Restoration, creation and enhancement projects are helping to undo the damage done to seagrass beds, but, as with any ecosystem, the goal should be to prevent damage in the first place.

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